Map algebra

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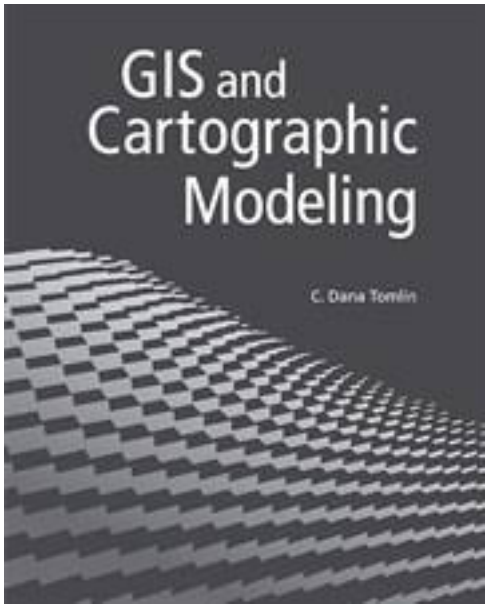
Learning objectives

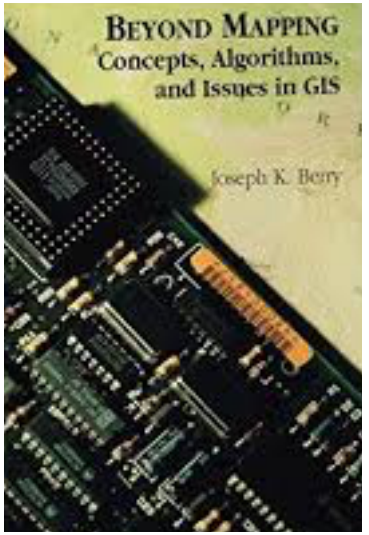
- Define map algebra.
- Explain the differences between and provide examples of local, focal, zonal and global map algebra operations.
- Construct a model diagram that captures the steps of a map algebra analysis.

Inventors of the concept

C. Dana Tomlin

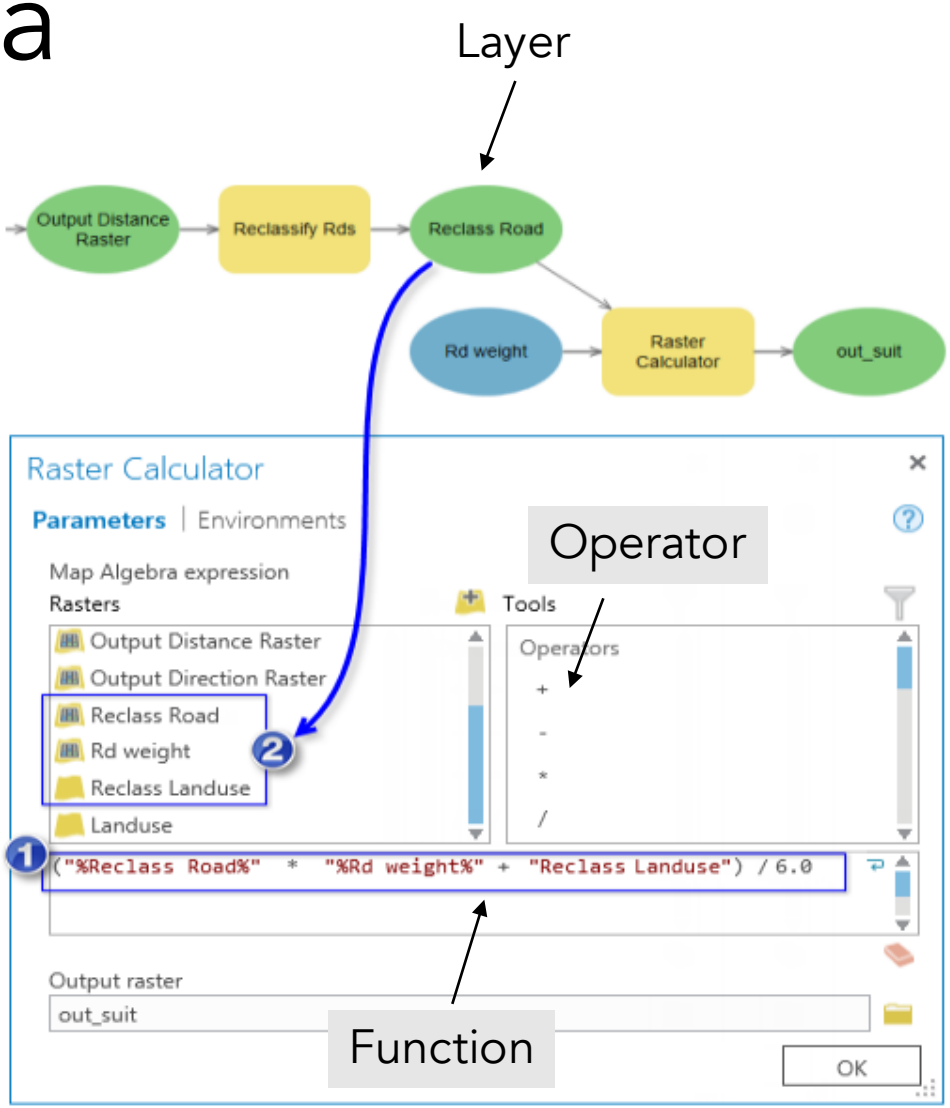


Joseph Berry
(mapematics)



The general idea

- Layers
  - Input(s)
  - Output(s)
- Operators
- Functions
  - More complex combinations of operators & layers

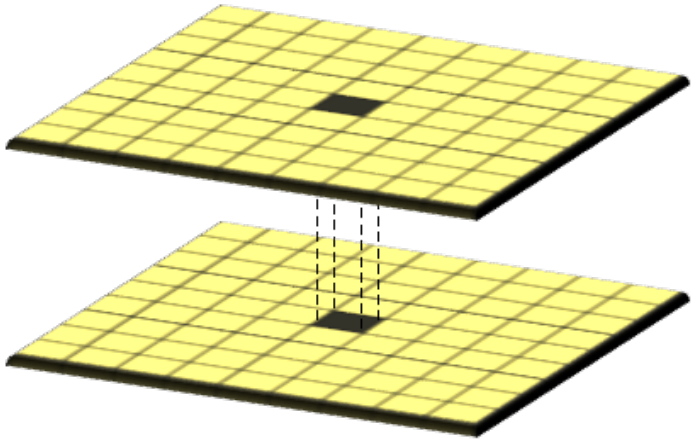


4 kinds of map algebra operations

- Local
- Focal
- Zonal
- Global

Decreasing scale (increasing size) of area required for the operation

Local Operations



Operates on a cell-wise basis (pixel by pixel).

1	4	5
5	3	2
2	5	2

+

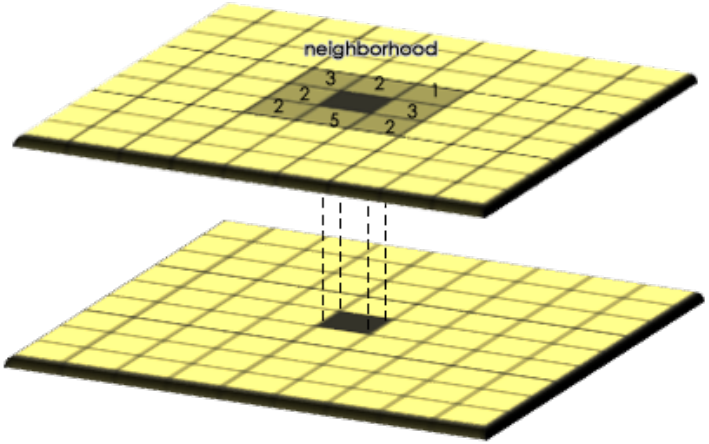
5	1	3
1	2	1
1	4	2

=

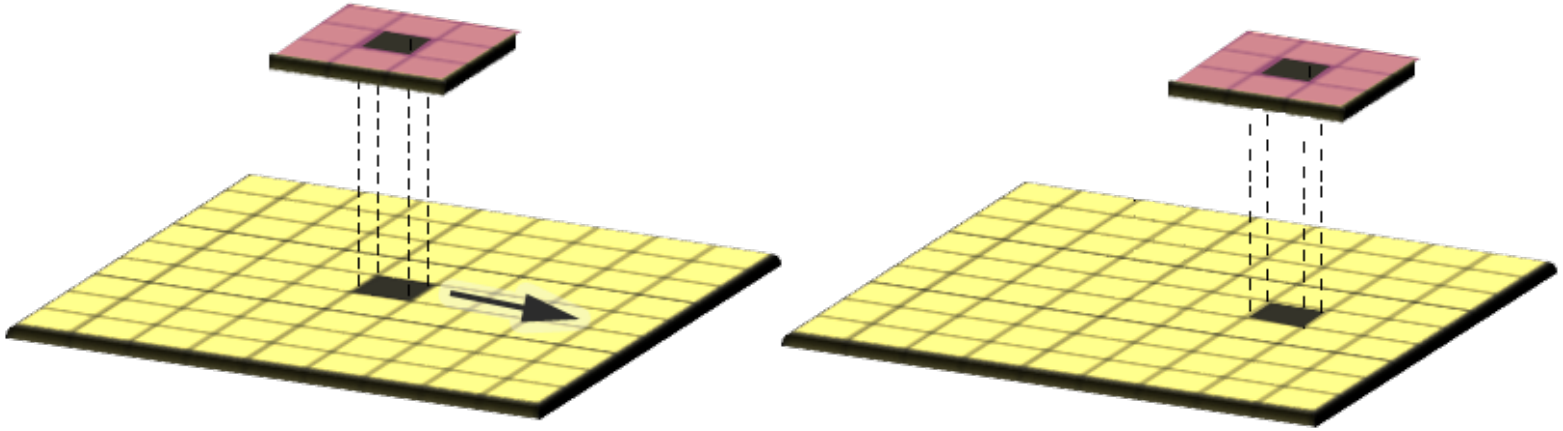
6	5	8
6	5	3
3	9	4

Arithmetic, Statistics, Relations, Trigonometric, Exponential/logarithmic, Reclassify

Focal Operations

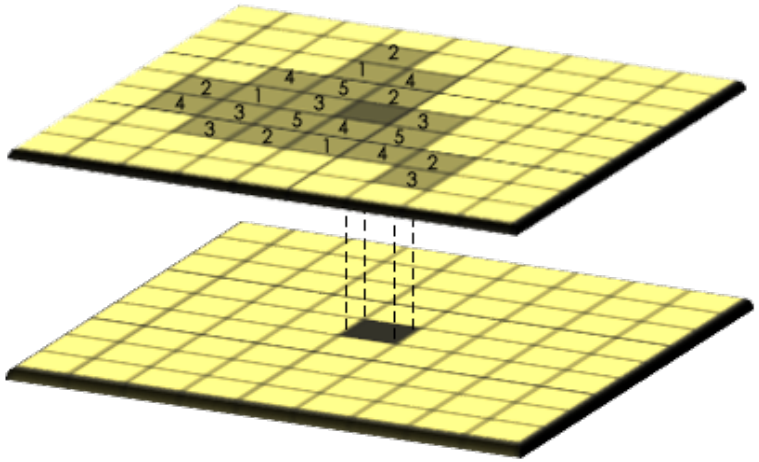


Operates on a cell using information from neighbours (window)



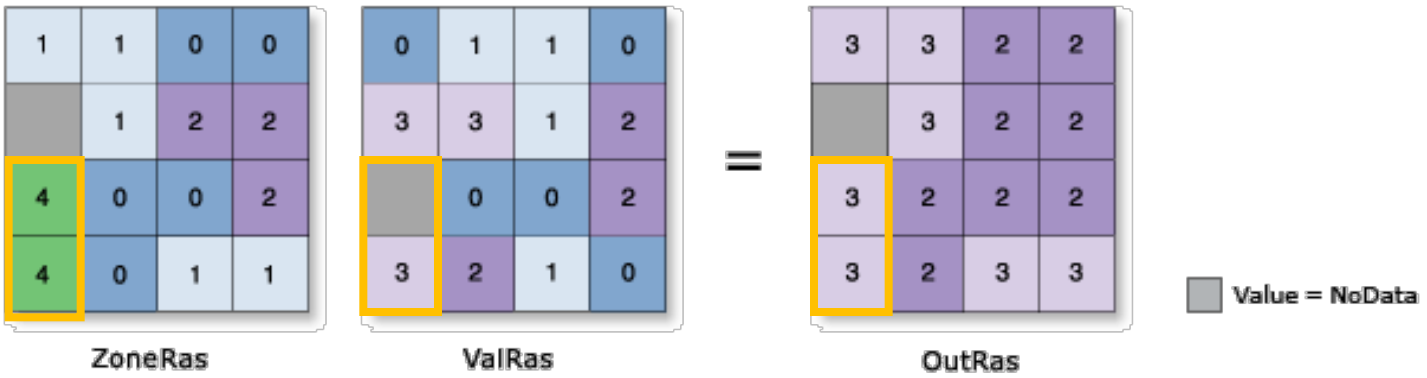
Examples: low-pass filter, slope, aspect

Zonal Operations

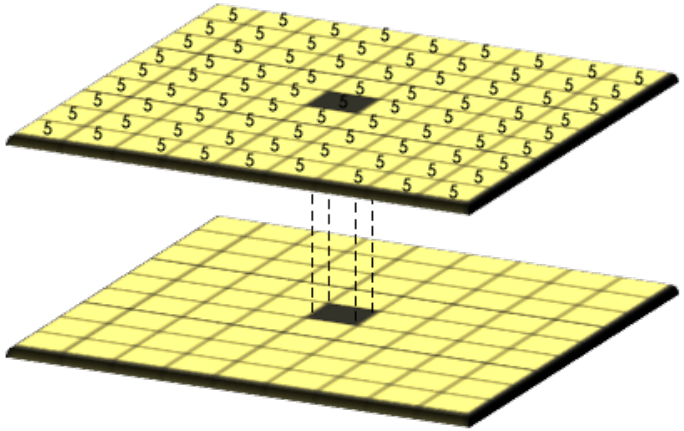


Performs an operation on a cell based on cells within a zone that contains that cell.

Example: calculate the maximum value in that zone.

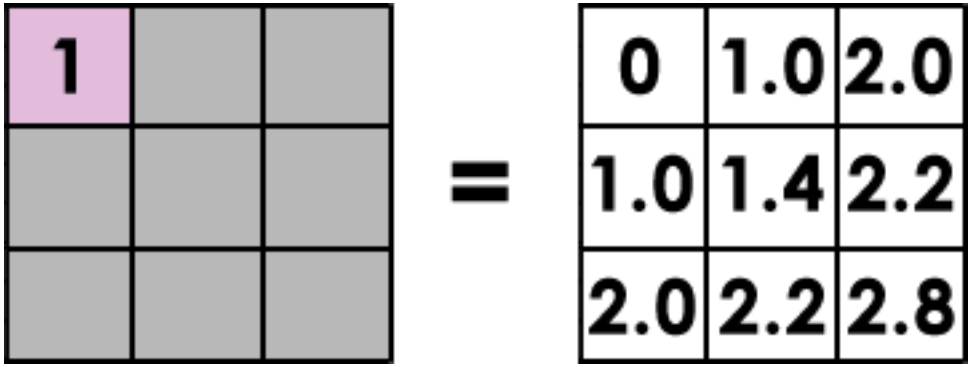


Global operations



An operation on an individual cell depends upon the values of ALL cells

example: Euclidean Distance operation



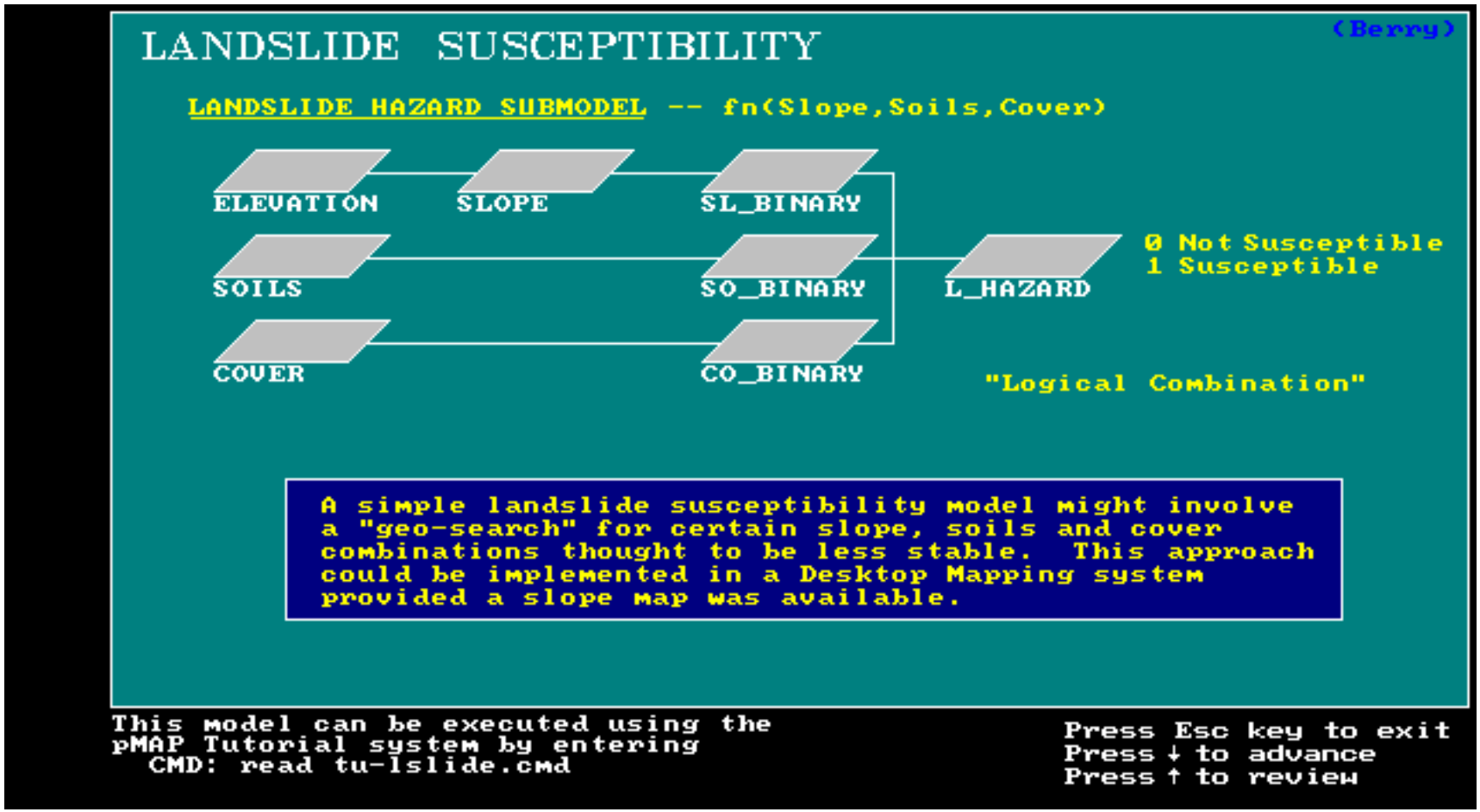
Prerequisites for Map Algebra

- Raster pixels need to line up across layers
  - Map projection needs to be the same
  - Spatial resolution needs to be the same

- Handling No Data values:
  - No Data + 1 = No Data
  - 0 + 1 = 0

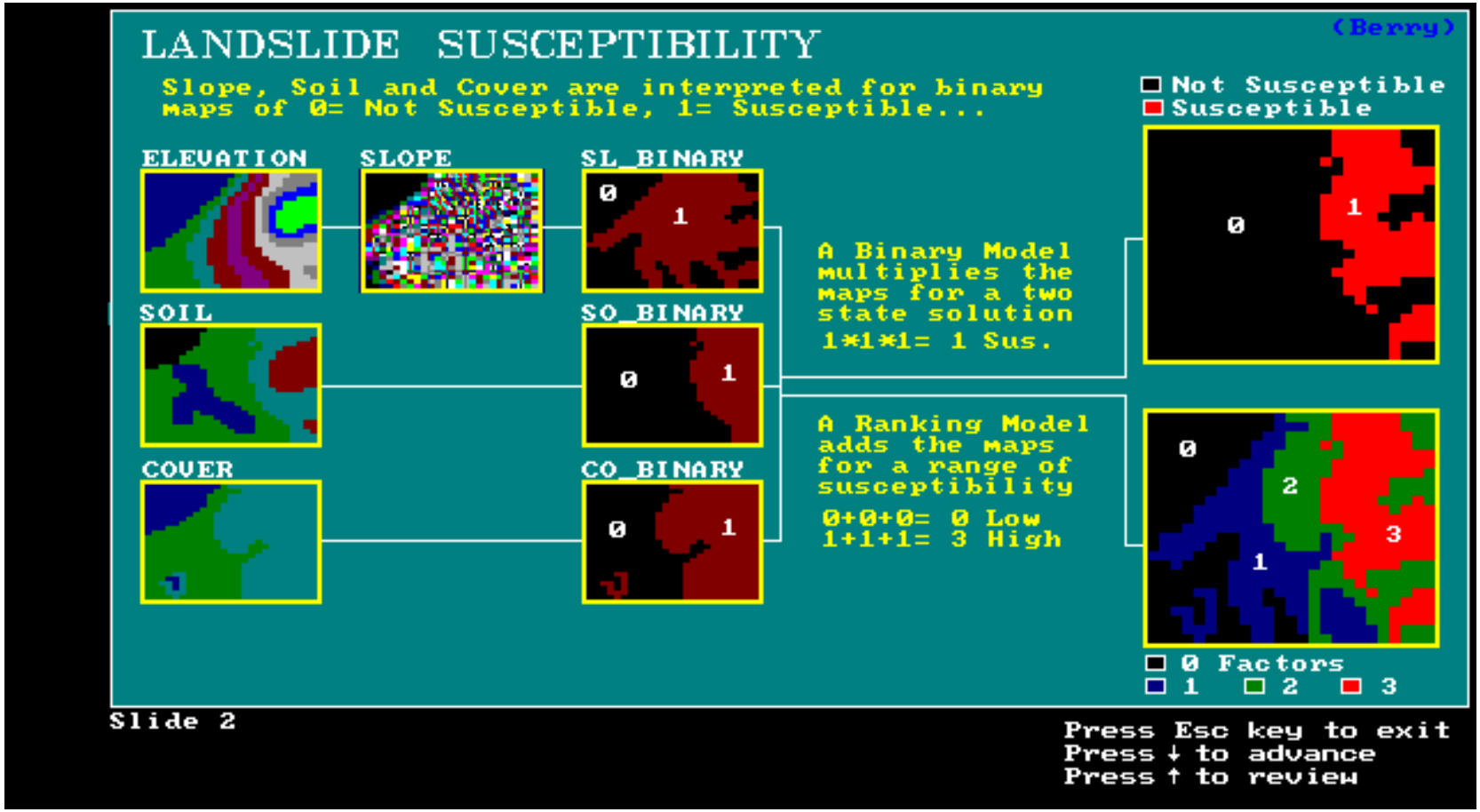
Examples

(from Berry's Tutorial Map Analysis Package)

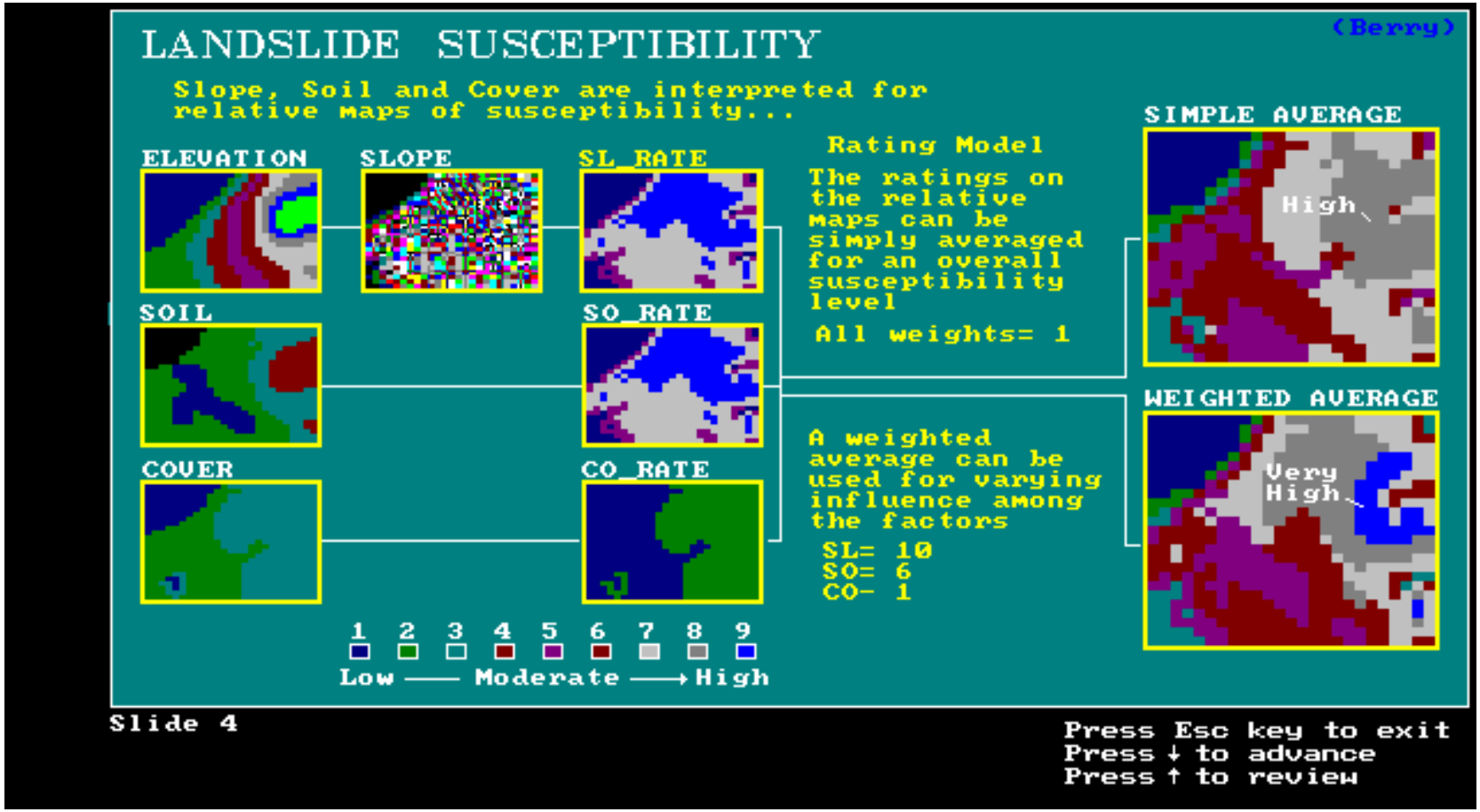


1 * 1 * 1 = 1 0 * 1 * 1 = 0

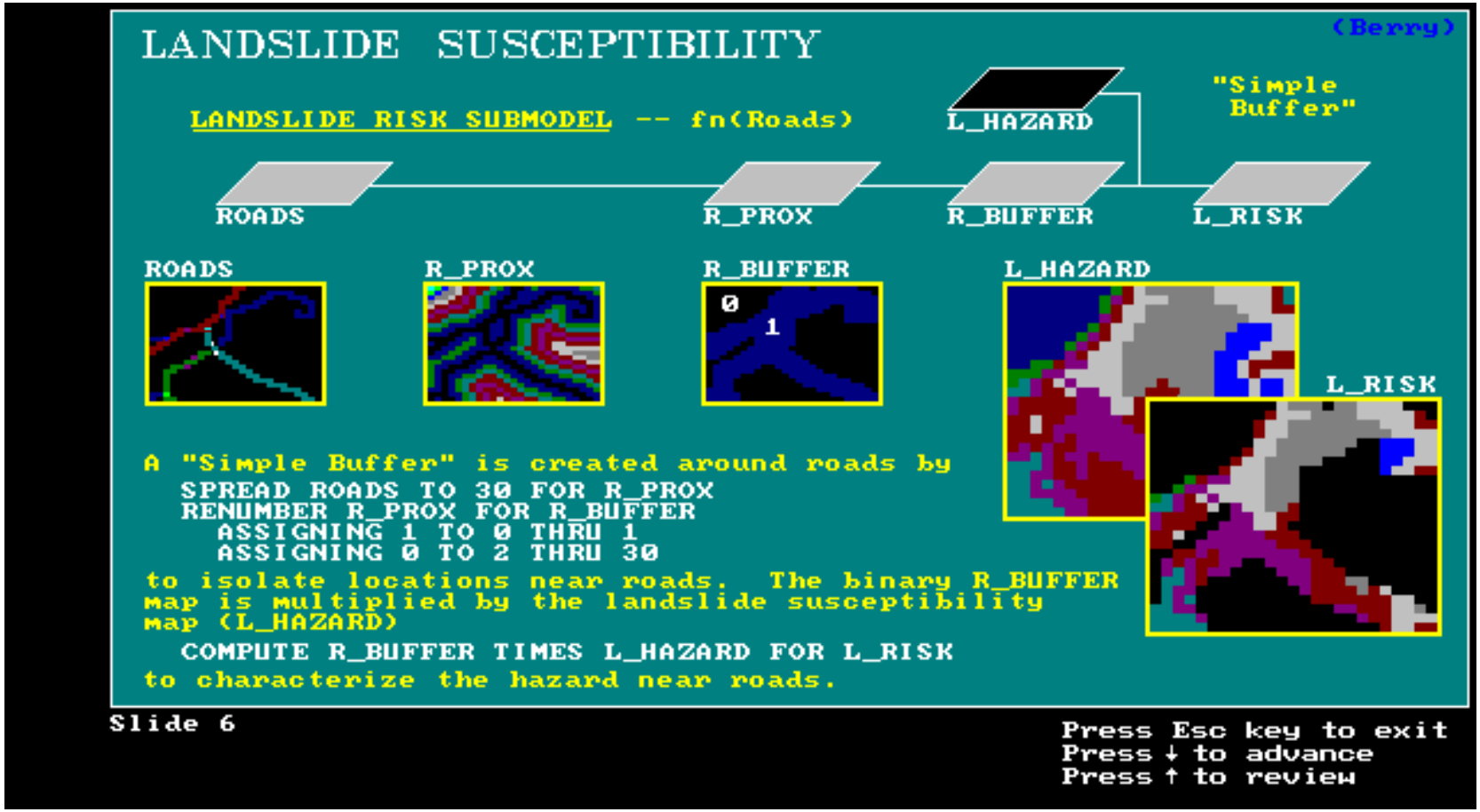
Still working with binary data, but adding instead of multiplying



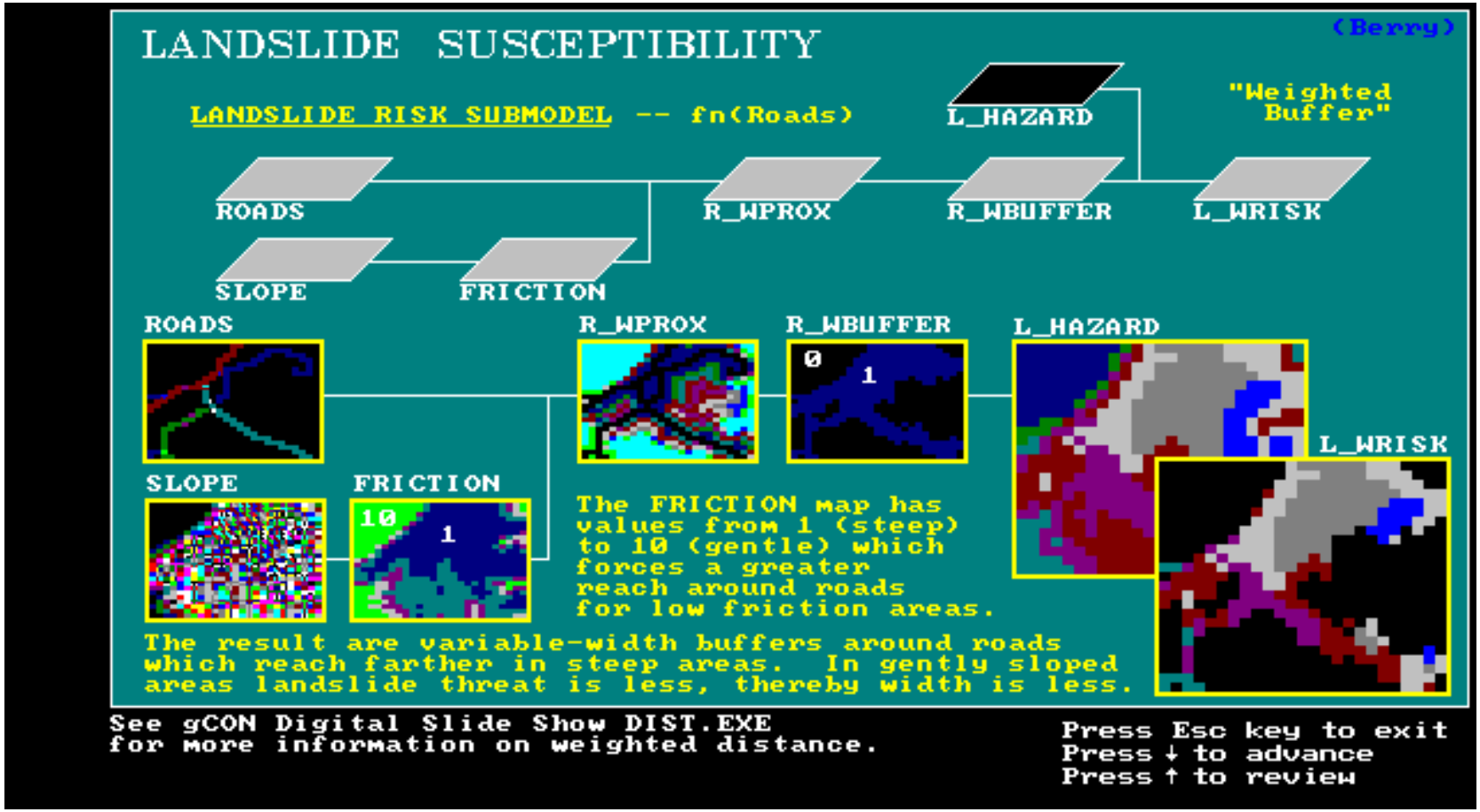
Rankings instead of binaries



Adding in proximity analysis (buffers)



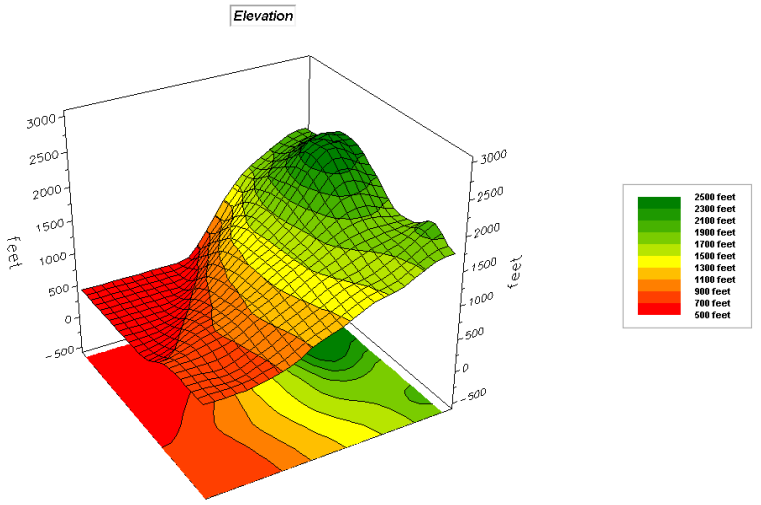
And make those buffer sizes depend on slope

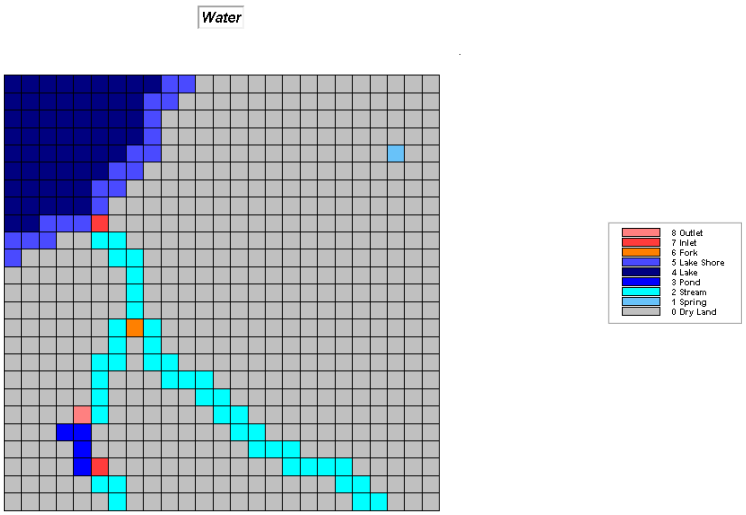


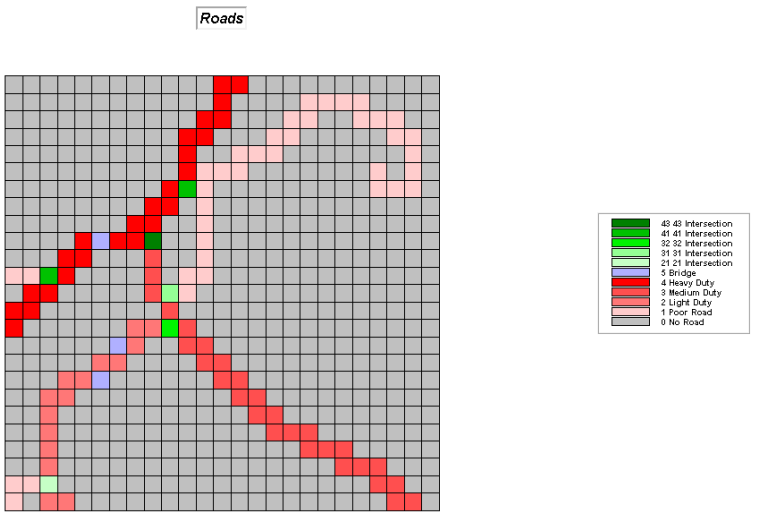
Map Algebra Inputs

Find 'best' campground location

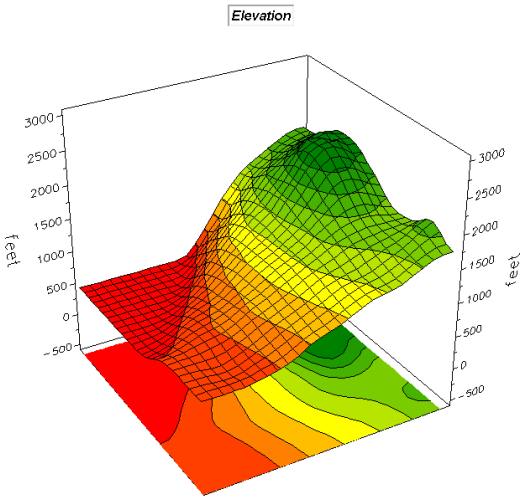
1) Gentle slope
2) Near roads
3) Near water
4) Good views of water
5) Westerly aspect

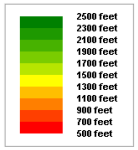


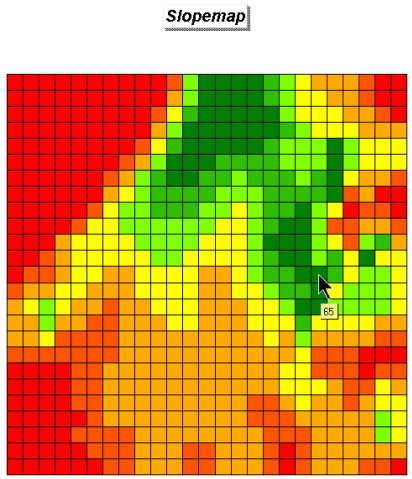


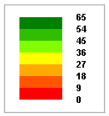


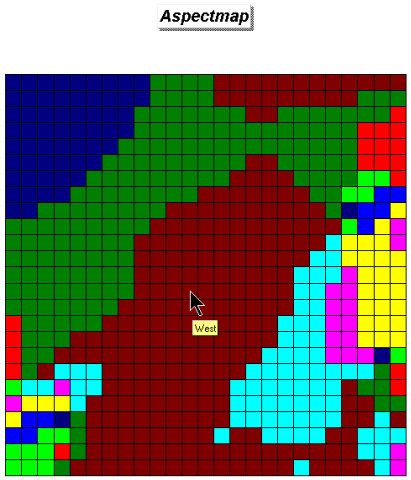
Derive criteria from inputs

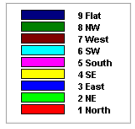




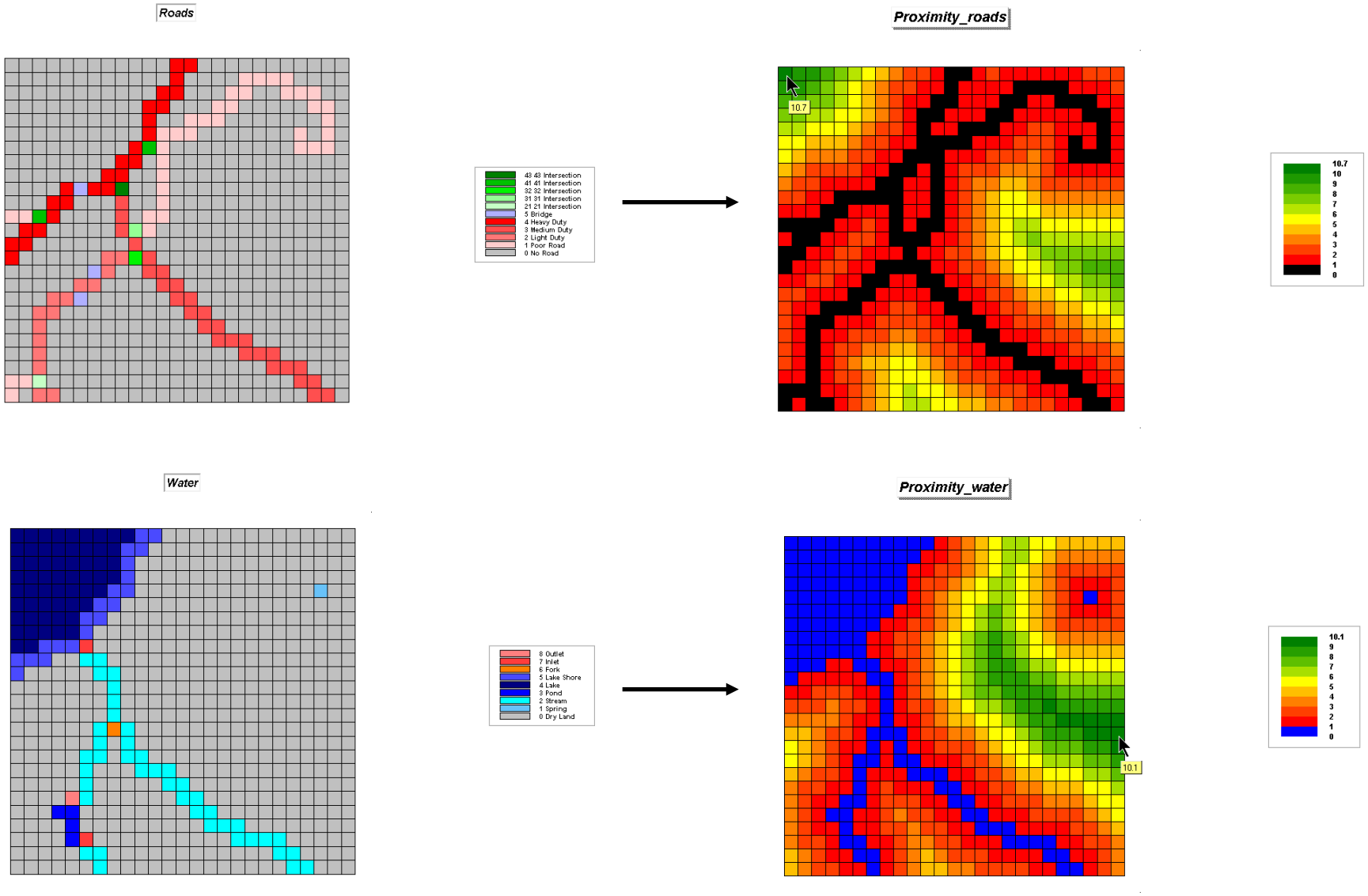




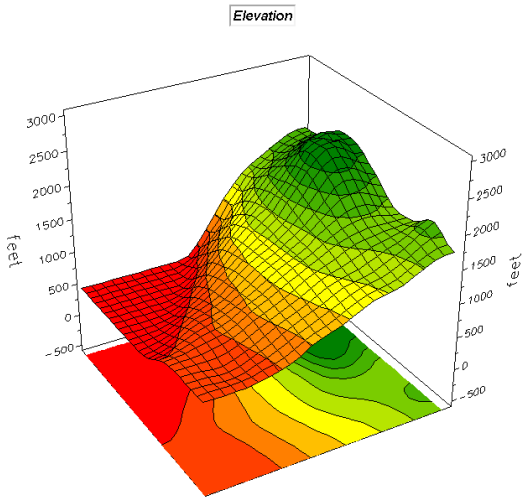


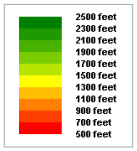


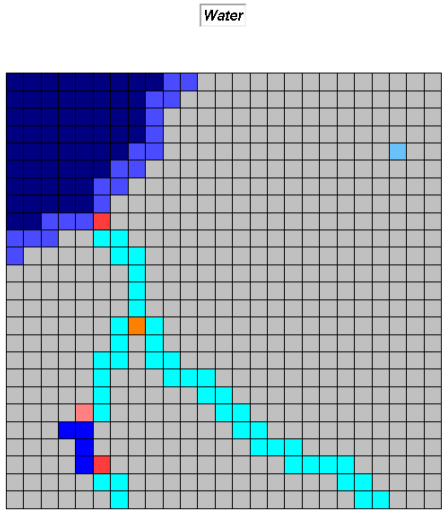
Derive criteria from inputs

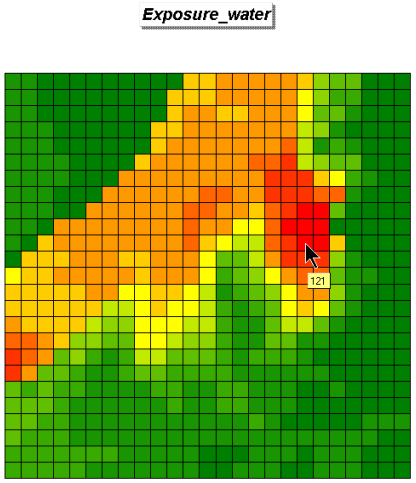


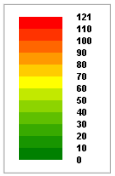
Derive criteria from inputs

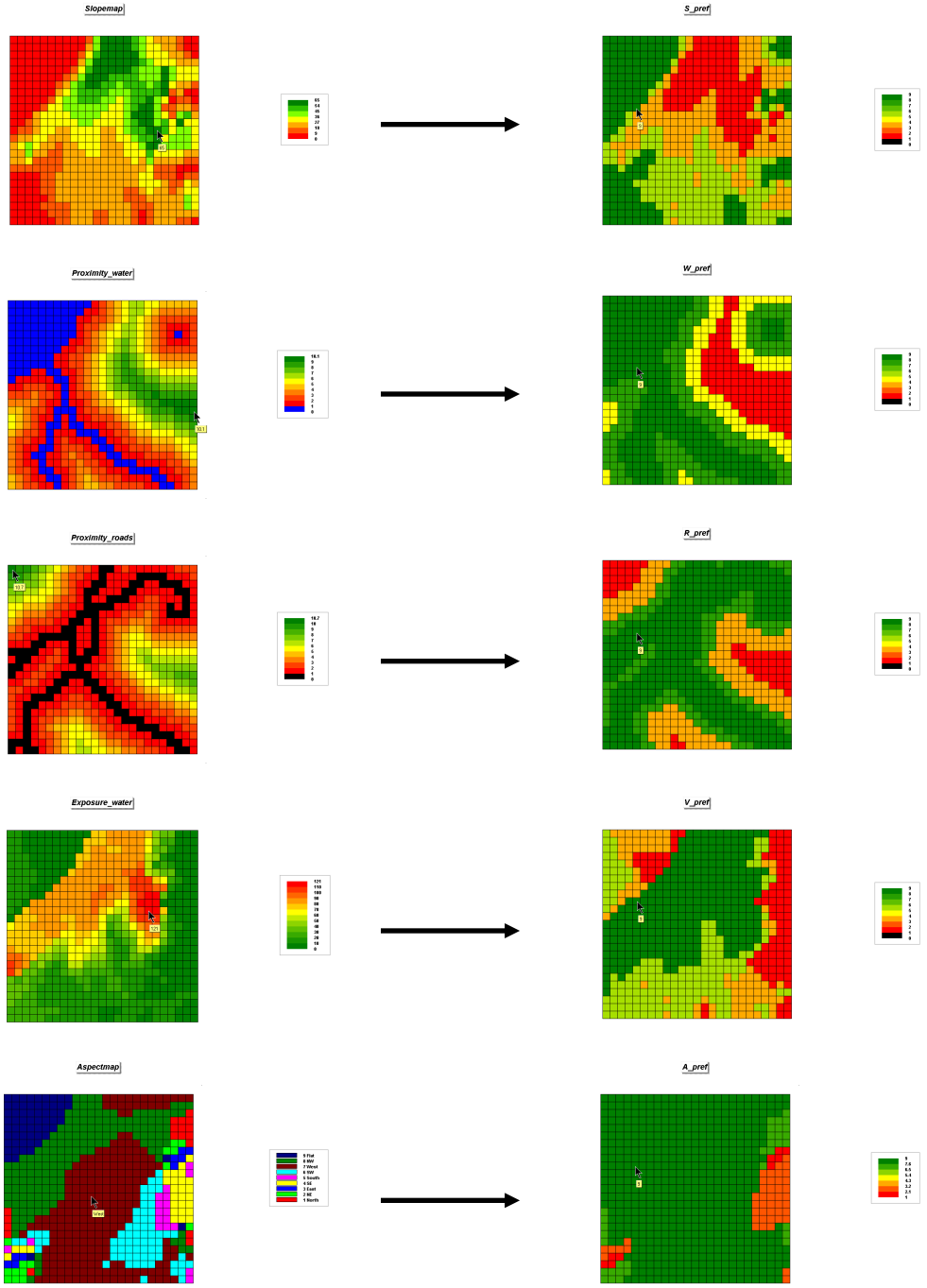






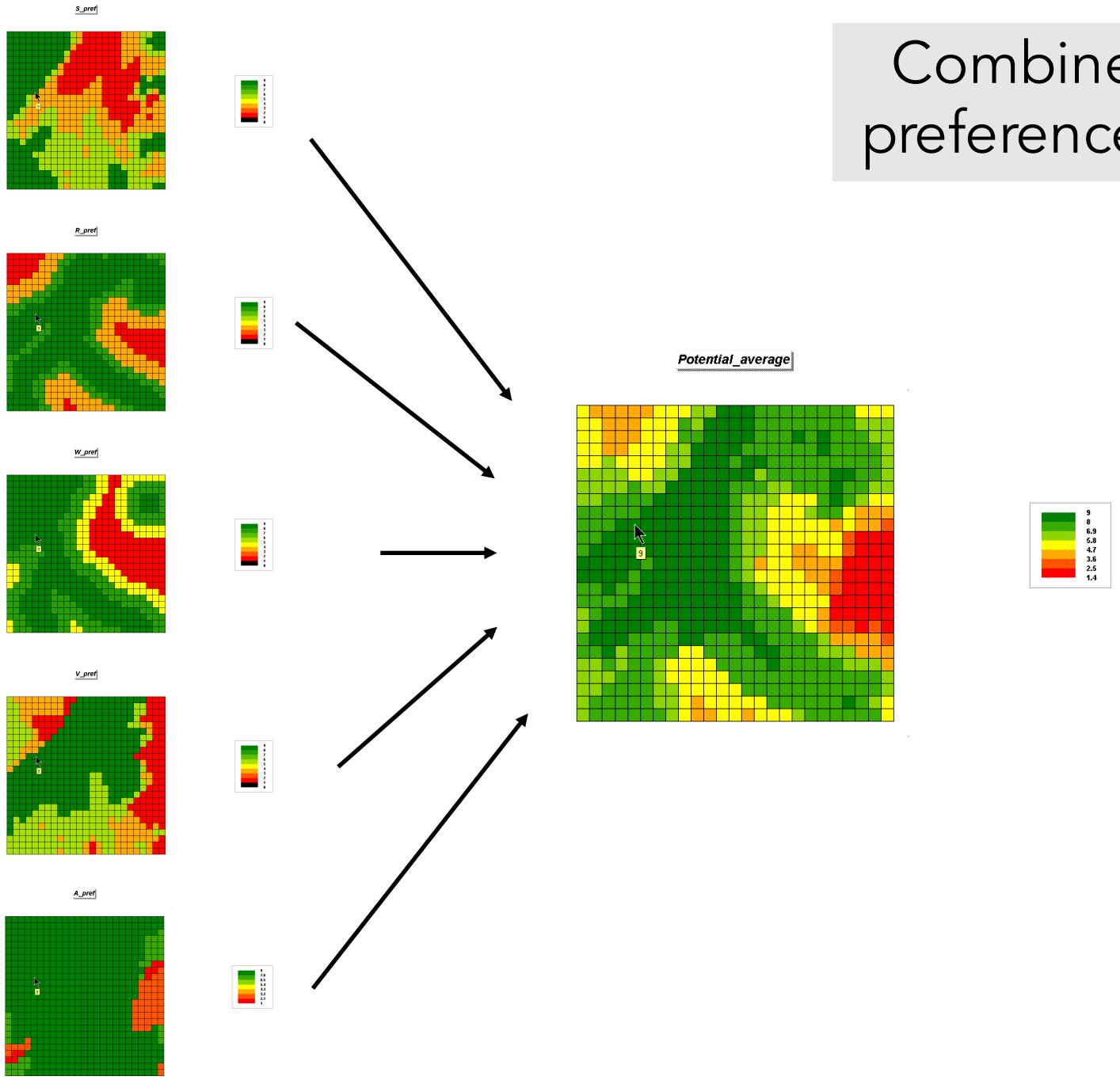






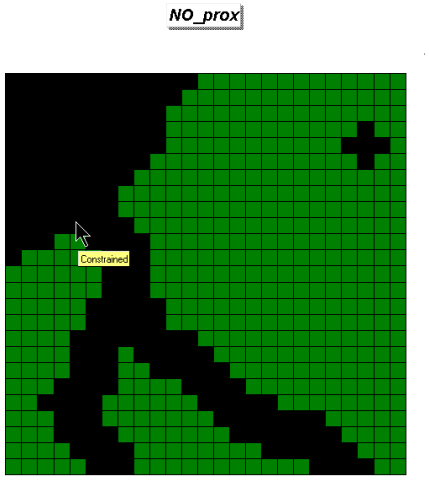
Derive preferences from criteria

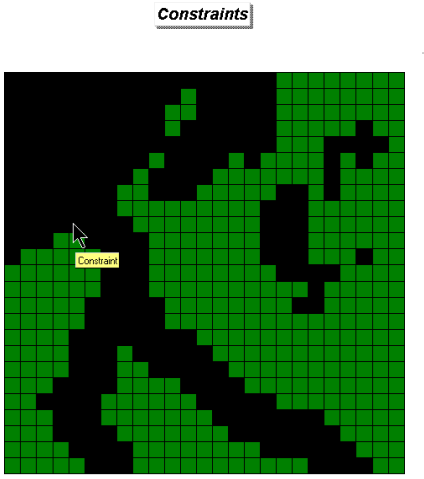
Combine preferences

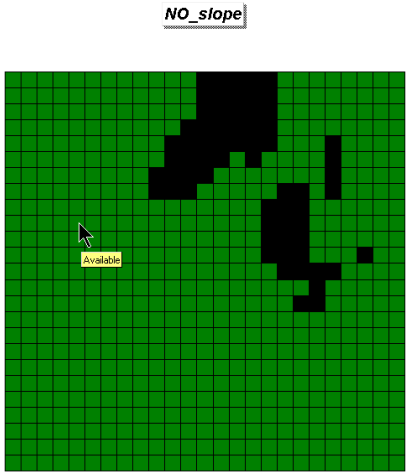


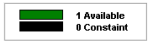
Constraints

Not too close to the road



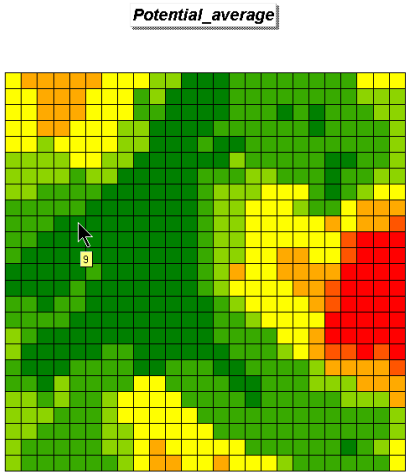


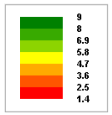


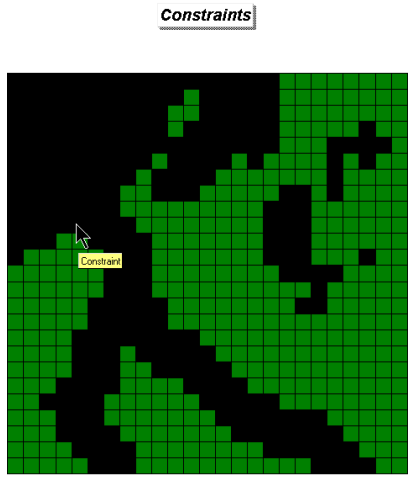


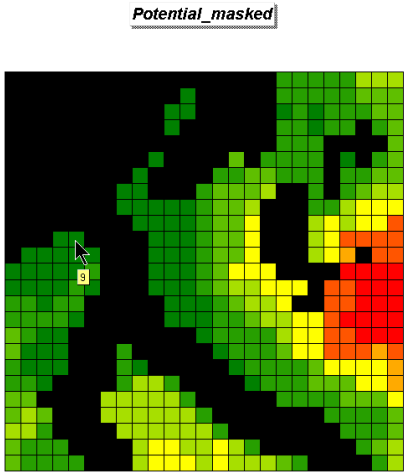
Not on slopes over 50%

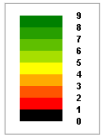
Combine constraints with preference map



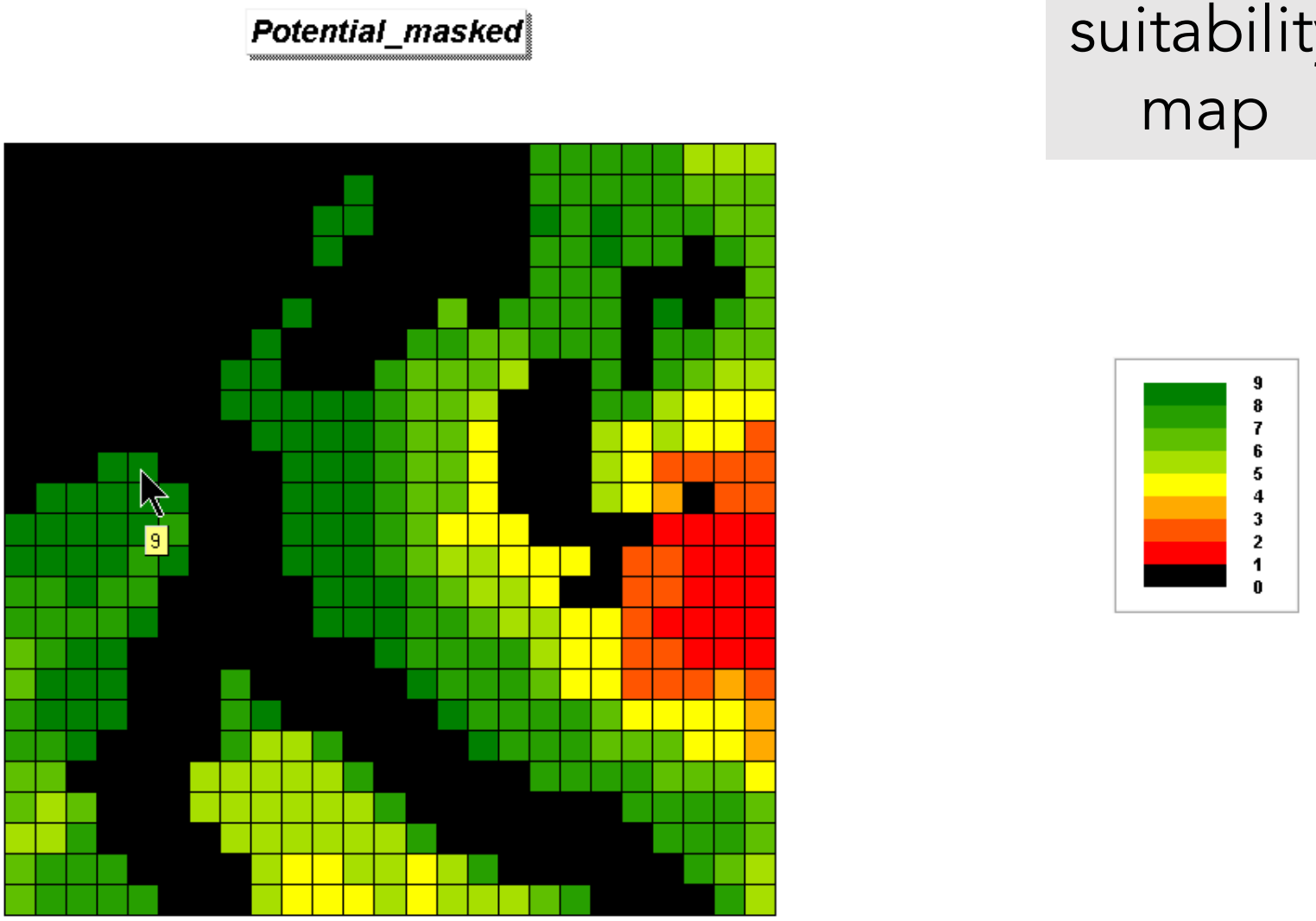








Final suitability map



Summary

- Map algebra takes multiple map layers and combines them using mathematical and logical operations.
- Pay attention to raster data requirements (same map projection, same spatial resolution).
- Multistep analysis with map algebra can build powerful models to solve multicriteria spatial problems.

References

- Berry, J., Reed, K.L. (2008). MapCalc Learner software. http://www.innovativegis.com/basis/MA_Workshop/MapCalc_download.htm Last accessed 24 April 2018.